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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Improvements in or relating to moulding of reinforced plastics articles.

COMPLETE SPECIFICATION

We, REICHHOLD CHEMIE AKTIENGESELLSCHAFT, a German Company of Hamburg-Wandsbek, Iversstrasse 57, Germany, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a mould for moulding reinforced plastics articles and also provides a process of moulding such articles utilising the mould.

By means of the process of the invention, articles of reinforced plastics material may be produced economically to a high standard of quality and with low expenditure on equipment.

Vacuum forming processes which have hitherto been used for moulding reinforced plastics are, in many respects, not wholly satisfactory.

One conventional vacuum forming process uses flexible extensible films and/or rubber sheets to force the moulding material against a rigid mould member.

When using this process, however, it is not possible to produce articles which have a smooth surface on both sides. A further disadvantage is as follows: the films or sheets do not accurately follow the contours of corners and recesses and, as a result, resin pockets are formed which are detrimental to the quality of the moulded articles. Under the influence of vacuum, the films or sheets often touch the upper edges of the rigid mould prematurely and, as a result, hinder the removal of air from the parts of the mould which lie below these edges. In order to achieve complete removal of the air, it is therefore necessary to incorporate parting films and porous materials, e.g. a jute weave, in the flexible films or sheets.

Manipulation of a multi-layer construction of this type is very awkward. Additionally, certain parts of the films or sheets only come to rest against the rigid mould under the influence of vacuum after having travelled a considerable distance. This easily results in displacement of the inserted reinforcing layer.

Some of these defects can admittedly be overcome by the use of a rigid mould member which is pressed against the main mould member with the aid of a film or sheet, under the influence of a vacuum. However, the manipulation of an outer mould, a rigid inner mould, an intermediate frame, an elastic film and a tensioning frame is very awkward and time-consuming and is frequently not reconcilable with the production requirements applying to the use of thermosetting, rapidly hardening plastics.

According to the present invention there is provided a mould which comprises shaped male and female mould halves enclosing an air-space for receiving the material to be moulded and having a peripheral air-tight seal between the mould halves, the peripheral portions of one or both mould halves being resilient to an extent such that when the air-space is evacuated, the mould halves are drawn together and compress any material placed between them, while the shape of the remaining portions of the mould halves is substantially unchanged.

The invention includes a process for the production of articles of reinforced plastics material which comprises changing a mould in accordance with the invention with reinforcing material impregnated with a liquid hardenable plastics material, evacuating the air-space between the mould halves and maintaining the vacuum in the air-space until the plastics material has hardened.

The process may, for example, be carried out by filling the reinforcing material, impregnated with the liquid hardenable plastics material, into the female mould half, then placing the male mould half against it, sealing off, evacuating the space between the two mould halves and holding it under

vacuum until the plastics material is sufficiently hardened.

The spacing of the mould halves during moulding and after evacuation is determined in the normal manner by the shape and dimensions of the mould halves.

The peripheral portions only of one or both mould halves are resilient under the forces exerted during the moulding operation so that the shape of those parts of the mould halves which are brought into contact with the moulding material does not alter during the moulding operation. Preferably the peripheral portions of the mould halves are so shaped as to form an annular cavity which is resiliently deformed when the air-space between the mould halves is evacuated.

Conveniently the annular cavity is provided with a port through which the air-space between the mould halves can be evacuated and the base of the annular cavity is advantageously formed with an annular recess for receiving excess material squeezed out from between the mould halves on evacuation of the air-space.

One or both mould halves may be provided with an inlet port for supplying liquid plastics material to the air-space between the mould halves and with this construction the reinforcing material may be impregnated with the liquid plastics material as the air-space is being evacuated.

The mould halves are preferably sealed with a gasket made from highly compressible material so that the extent of movement of the mould halves on evacuating the air-space.

It is surprising that the reduction of the spacing of the mould halves by only a few millimeters (which the two mould halves traverse when the air-space is evacuated) suffices to achieve proper moulding of the reinforced plastics material.

The process of the present invention has the advantage that the initially present dead air-space between the mould halves is only a fraction of the air-space which is present in many conventional vacuum forming processes.

As a result, the action of vacuum-ballast vessels or of the vacuum pump used is much more powerful and comes into full force in a significantly shorter period. The vacuum normally required is approximately 650 to 730 mm mercury below atmospheric pressure, though values above and below this may be used. A vacuum of approximately 700 mm mercury below atmospheric pressure is preferred.

By constructing the two mould halves in accordance with the invention, it is possible to maintain a uniform wall thickness, or, by forming recesses in one mould half only, it is possible to achieve an increased thickness of material required in certain positions. The degree of reinforcement achievable by this process is, in the case of glass fibre materials, approximately 40-50% glass content in the finished plastic article, whereas, with the vacuum forming processes hitherto used, a glass content of only 25-30% was achievable.

To remove the article from the mould, inlet ports may be provided in one or both of the mould halves and by forcing water, for example, through the ports easy mould release of the moulded article is achieved.

Examples of suitable reinforcing materials are mats and woven fabrics, e.g. of sisal, as well as textiles, insulating mats of slag wool and jute although glass fibre mats and woven glass cloth are preferred. When using glass mats which contain binder, care must be taken that the mats used for the process of the invention are such that their binder does not lose its mechanical strength in the liquid plastics material.

Examples of liquid hardenable plastics materials are unsaturated polyester, epoxide, and methyl methacrylate resins.

Suitable materials for the mould halves are e.g. glass fibre reinforced plastics, thermoplastics, and metal sheets with or without protective coatings.

The mould, which may be taken apart, consists of two mould halves, at least one of which has a resilient section outside the zone which serves to mould the article. This resiliency is sufficient for the mould halves to reduce their spacing to a predetermined distance, at least in the moulding zone, when the mould halves are charged and vacuum is applied.

The mould halves are of the design and dimensions normally used in mould construction in that part which serves for moulding.

Two moulds constructed in accordance with the invention are illustrated in the accompanying drawings in which:

Figure 1 is a fragmentary view of a section through a mould in accordance with the invention,

Figure 2 is a fragmentary view of a section through the mould shown in Figure 1 after evacuation of the air-space,

Figure 3 is a fragmentary view of a section through a modified mould to that shown in Figure 1,

Figure 4 is a fragmentary view of a section through the mould shown in Figure 3 after evacuation of the air-space and

Figures 5 and 6 are fragmentary views of a different modified form of the mould shown in Figure 1.

Referring to the drawings, Figure 1 shows a part of a bucket-shaped mould comprising a rigid female mould half 1 and a male mould half 2 which is also rigid except for a resilient portion 7. At the periphery of the mould, the two mould halves enclose an annular cavity 6 and a conduit 5 is connected to a port in the roof of the cavity and

permits the evacuation of the air-space between the mould halves. A gasket 3 of elastomeric material is clamped between the two mould halves at their peripheral edges by clamps not shown. An annular recess is provided in the base of the annular cavity for receiving excess material squeezed out from between the mould halves on evacuation of the air-space.

The modified form of mould shown in Figures 3 and 4 differs from that shown in Figures 1 and 2 only in that the male mould half is entirely rigid, while the female mould half has a resilient portion 7.

The modified mould illustrated in Figures 5 and 6 is identical with that shown in Figures 1 and 2 except that each mould half is provided with a conduit 8 communicating with the air-space between the mould halves.

One method of producing a reinforced plastics article using a mould constructed in accordance with the invention consists in opening the mould and placing one or more layers of resin impregnated reinforcing material in the female mould half. The mould is then closed and the air evacuated through conduit 5 and this causes the two mould halves to be forced towards each other and compress the impregnated reinforcing material so that the mould takes up the position indicated in Figure 2. The vacuum is maintained until the resin has hardened sufficiently before the mould is opened and the moulded article released. When using the mould illustrated in Figures 5 and 6, the reinforcing material can be placed in the mould in an unimpregnated condition and the resin supplied to the reinforcing material through the conduit 8 as the air-space is being evacuated. When the resin has hardened the moulded article can be released by forcing air or water through conduits 8.

The following Examples in which parts and percentages are by weight are given to illustrate the manner in which the invention may be carried into effect using a mould in accordance with the invention:—

EXAMPLE 1:

The two mould halves of a glass fibre-reinforced polyester mould were coated with a parting agent—a hard wax dissolved in carbon tetrachloride—before starting the mould operation. Glass fibre mats, having a phenolic resin binder and weighing 450 g per m^2 were cut to shape and placed in the female mould half. Two layers, inserted dry into the female mould half, resulted in 6-7 mm thickness. The liquid used for the impregnation of the glass fibre was an unsaturated polyester resin produced by esterification of maleic anhydride and phthalic anhydride with propane diol. The resin was mixed with styrene in the ratio of 70:30 by weight and stabilised with hydroquinone in known manner. Before use, 10 parts of styrene were added to the resin per 100 parts of resin. Hardening at a temperature of 20°C was achieved by mixing in approximately 2% of an organic peroxide, preferably a hydroperoxide of the type of the methyl alkyl ketone peroxides, and 0.3% of accelerator based on a heavy metal salt, preferably the cobalt salts of octanoic acid and naphthenic acid.

The mixture so prepared was poured into the female mould half and the male mould half was placed on top of it. When the mould halves had been bolted together to be air and vacuum tight, the mould was evacuated by means of the conduit provided for this purpose, to 700-730 mm mercury below atmospheric pressure. As a result of the resiliency of one or both of the mould halves in the region of the annular cavity and the differential of pressure between the interior and exterior of the mould, the two mould halves approached one another so that the cut mat of 6-7 mm thickness which had been inserted was compressed to the intended thickness of 2 mm; at the same time, the unsaturated polyester resin permeated throughout the whole of the mats to drive out any pockets of air. The required wall thickness was maintained at all parts of the finished article.

The removal of the moulded article from the mould after curing can be carried out without much trouble. Figures 5 and 6 show that conduits are provided in both mould halves which may be used for releasing the article from the mould by means of water, and will also permit the liquid resin used in the mould for impregnation of the reinforcing material to be taken from a vessel standing outside the mould. The product so produced had a glass content of 45% of total volume.

EXAMPLE 2.

The two mould halves were coated with a parting agent—a so-called parting film based on an aqueous solution of polyvinyl alcohol.

The reinforcement used was an alkali-free glass fabric woven with the same warp and weft.

As in Example 1, two layers of dry fabric were inserted into the female mould half.

The liquid resin used was an epoxide resin with an epoxide equivalent weight of 185-200, consisting of a mixture of 20 parts of a resin produced by condensation of bisphenol A and epichlorhydrin in an alkaline solution and 10 parts of butyl glycidyl ether, mixed with triethylene tetramine in a 100:12 ratio by weight. The mixture had a pot life of 40-50 minutes.

As in Example 1, it was again found in this case that because of the resilient properties of a part of the mould halves forming

the annular cavity, the impregnated fabric could be compressed to the required wall thickness of 2 mm. The degree of impregnation was satisfactory and the wall thickness of the finished article provided for in the construction of the mould halves was achieved.

In the case of the epoxide resin, it is again possible to draw the material into the mould from a vessel standing outside the mould shells, via the conduits in the mould halves.

WHAT WE CLAIM IS:

1. A mould which comprises shaped male and female mould halves enclosing an air-space for receiving the material to be moulded and having a peripheral air-tight seal between the mould halves, the peripheral portions of one or both mould halves being resilient to an extent such that when the air-space is evacuated, the mould halves are drawn together and compress any material placed between them, while the shape of the remaining portions of the mould halves is substantially unchanged.

2. A mould according to claim 1 wherein the peripheral portions of the mould halves are shaped so as to form an annular cavity which is resiliently deformed when the air space between the mould halves is evacuated.

3. A mould according to claim 2 wherein the annular cavity is provided with a port through which the air-space between the mould halves can be evacuated.

4. A mould according to claim 2 or 3 wherein the base of the annular cavity is formed with an annular recess for receiving excess material squeezed out from between the mould halves on evacuation of the air-space.

5. A mould according to any of the preceding claims wherein one or both of the mould halves is provided with an inlet port for supplying liquid plastics material to the air-space between the mould halves.

6. A mould according to any of the preceding claims wherein the airtight seal comprises a gasket made from highly compressible material so that the extent of movement of the mould halves on evacuating the air-space is increased.

7. A mould substantially as described with reference to the accompanying drawings.

8. A process for the production of articles of reinforced plastics material which comprises charging a mould as claimed in any of the preceding claims with reinforcing material impregnated with a liquid hardenable plastics material, evacuating the air-space between the mould halves and maintaining the vacuum in the air-space until the plastics material has hardened.

9. A process according to claim 8 wherein the reinforcing material is impregnated while the mould is being evcauated by supplying the liquid hardenable plastics material through one or more inlet ports in the mould halves.

10. A process according to claim 8 or claim 9 wherein the air-space between the mould halves is evacuated to a pressure of 650 to 730 mms of mercury below atmospheric pressure.

11. A process for the production of articles of reinforced plastics material substantially as described with reference to the Examples.

STEVENS, LANGNER, PARRY & ROLLINSON,
Agents for the Applicants.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG.1

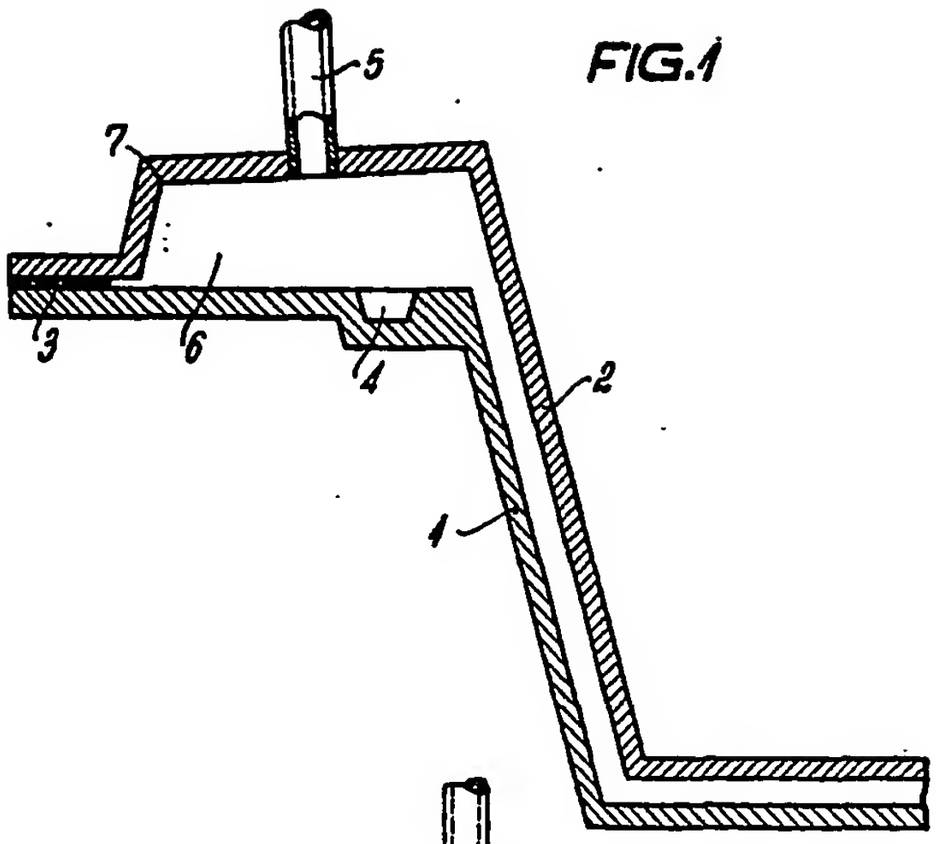
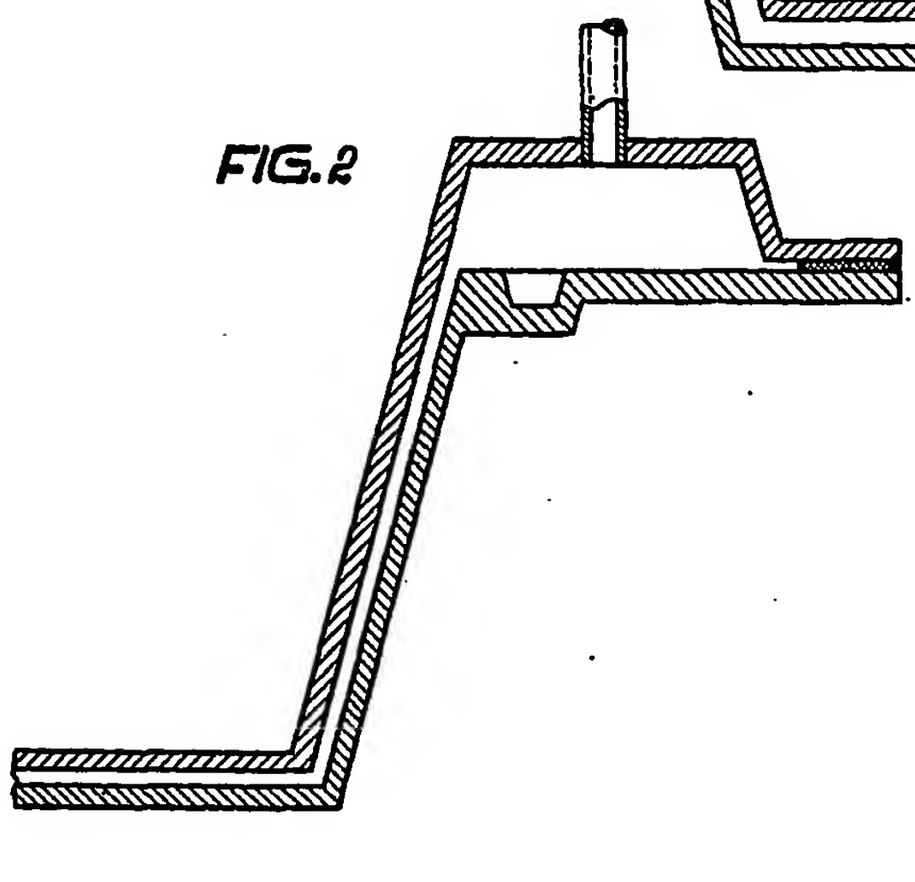


FIG.2



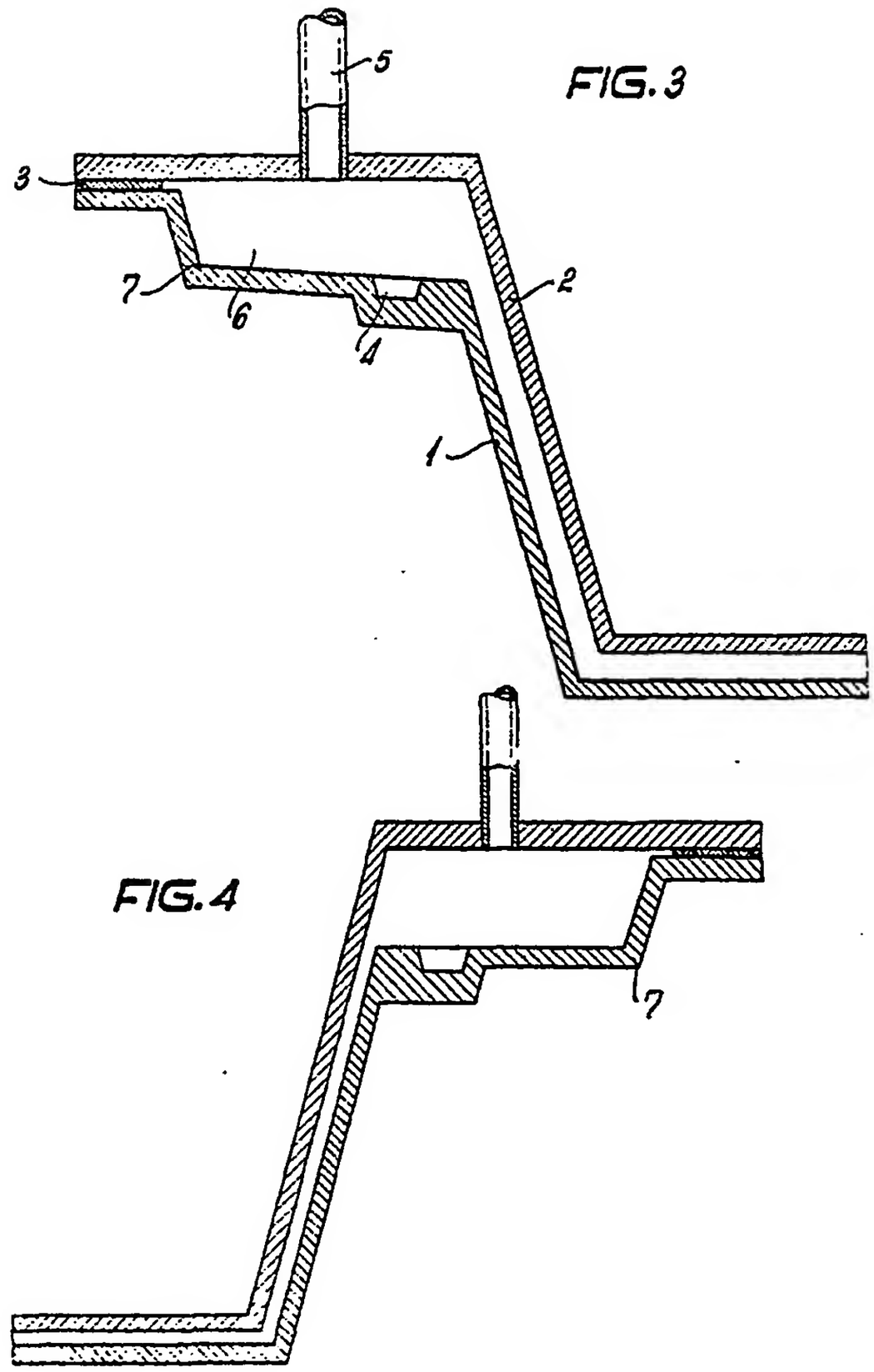


FIG. 3

FIG. 4

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Sheets 2 & 3

FIG. 3

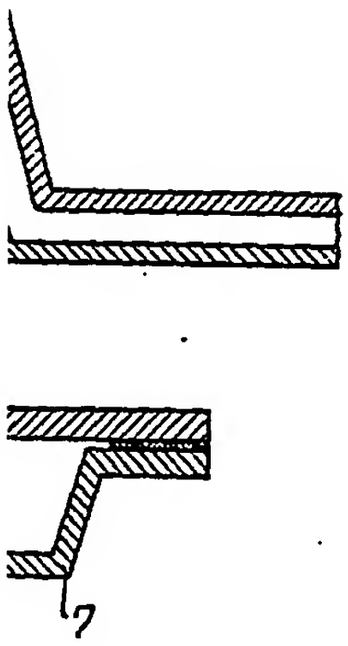


FIG. 5

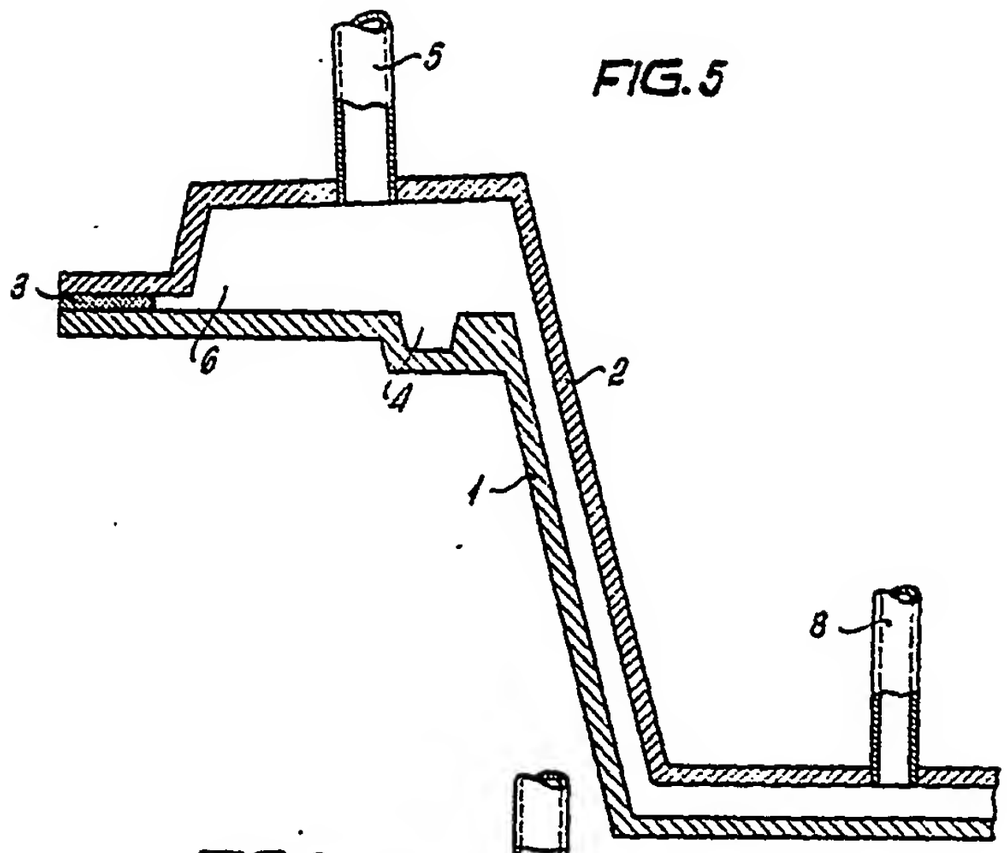
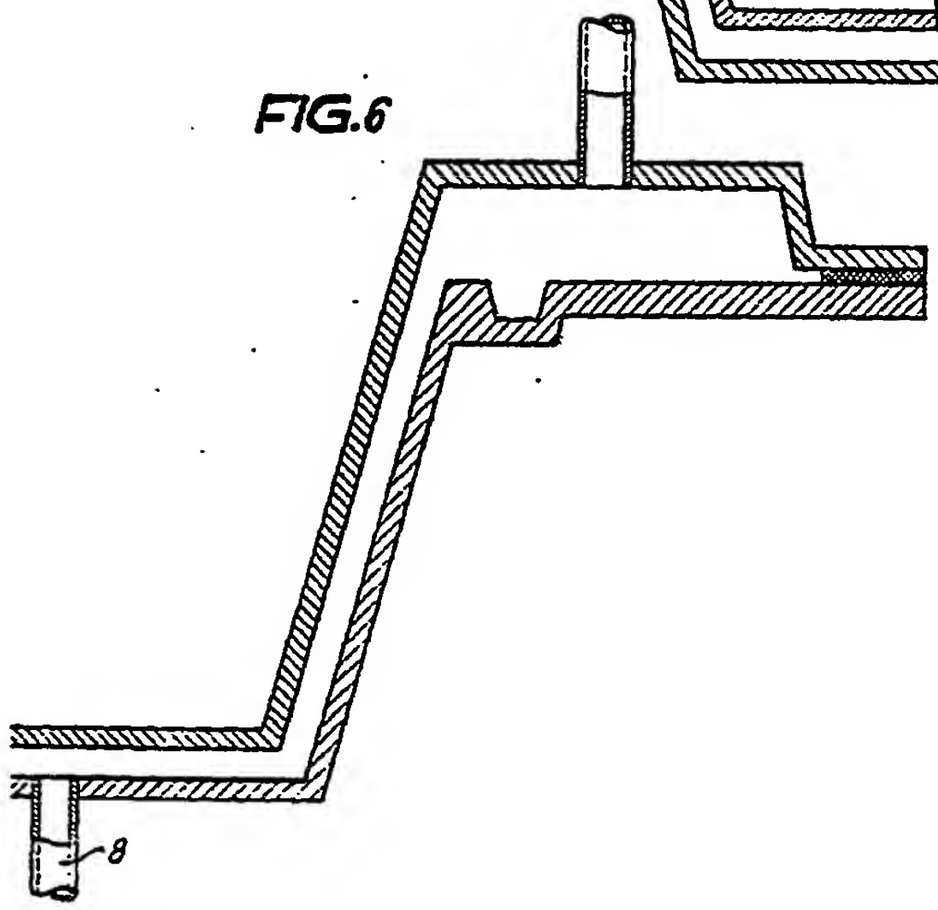


FIG. 6



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 2 & 3

FIG. 3

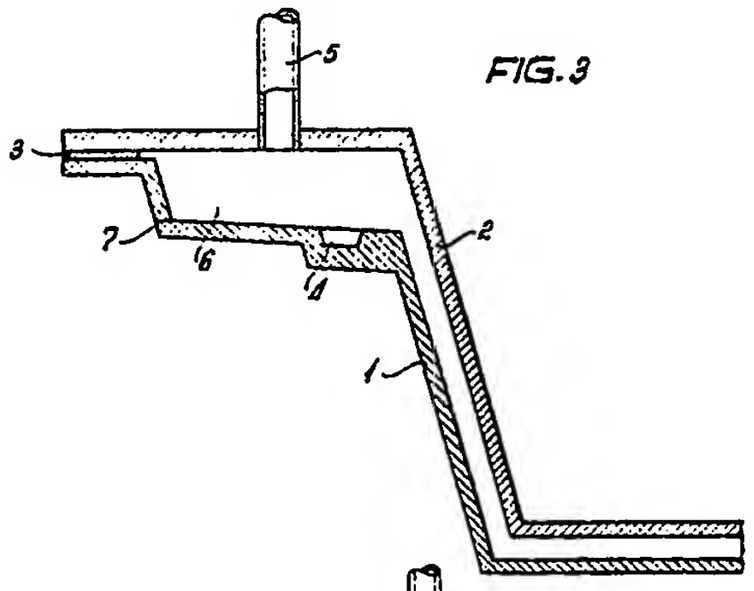

FIG. 4

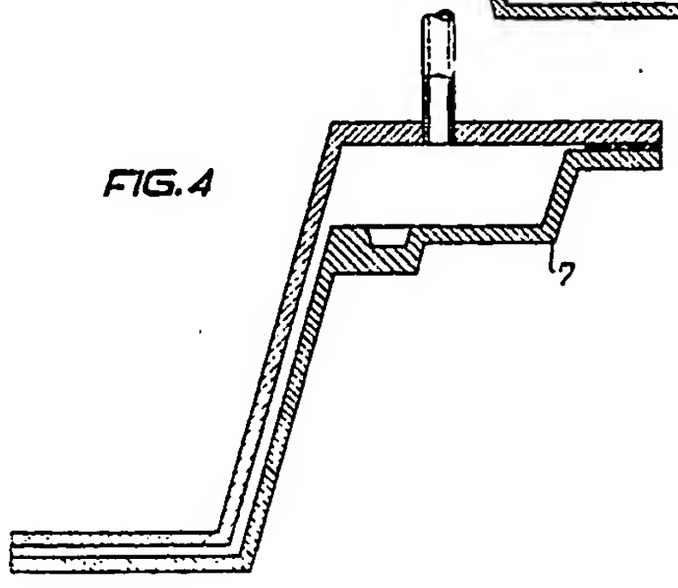

FIG. 5

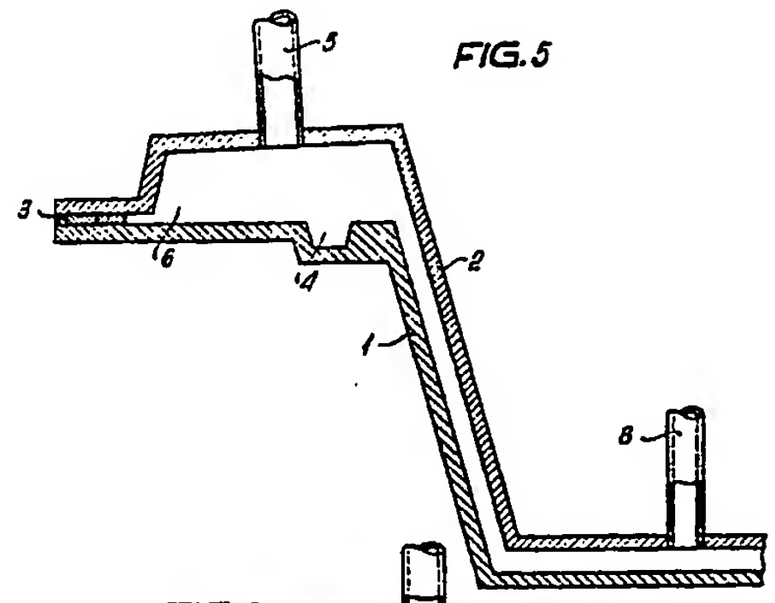

FIG. 6